BULLETIN

OF THE INSTITUTE OF METALS

VOLUME 2 APRIL 1954 PART 8

INSTITUTE NEWS

Spring Meeting 26 April–1 May 1954

The programme of the Joint Spring Meeting with the Société Française de Métallurgie, to be held in London from Monday, 26 April to Saturday, 1 May (with extensions to the Provinces for members of the Société) was published in the February issue of the *Bulletin*. In addition, all members resident in Europe should by now have received a separately printed programme with Reply Form.

Members who intend to be present at any part of the meeting are requested to return their completed Reply Forms to the Secretary by 14 April if they have not already done so.

Grant of Arms

As previously announced, the Council has gratefully accepted an offer by the Directors of Johnson, Matthey and Co., Ltd., to present to the Institute a Presidential Badge, incorporating the Institute's Arms.

A grant of Arms to the Institute has now been made by the College of Heralds, and the expenses incurred have been kindly borne by the donors as part of the expenses of production of the Presidential Badge, which is to be presented to the Institute at the Annual General Meeting at Church House, Westminster, S.W.1, on the morning of Tuesday, 27 April.

A black-and-white reproduction of the Arms of the Institute is given above. A colour plate of the Arms will be published in the *Journal* at a later date.

Official Blazon of the Arms : Per pale Or and Argent an open book proper thereon the alchemical signs for the non-ferrous metals Sable And for the Crest on a Wreath Or and Sable, Issuant from flames a crucible emitting Oxide vapour proper.

Supporters : Griffins, traditional guardians of treasure.

Motto : De Re Metallica.

Election of Members

The following 20 Ordinary Members, 2 Junior Members, and 11 Student Members were elected on 26 February 1954 :

As Ordinary Members

BERWICK, John Duncan, Jr., B.S., Chief Metallurgist, Research, Western Brass Mills, Metals Division, Olin Industries, Inc., New Haven, Conn., U.S.A.

BURFITT, Sidney William, Manager, Process Heating Department, Midland Area, The General Electric Co., Ltd., Moor Street, Birmingham 4.

CARRO CAO, *Professor* Giuseppe, Dr.Mech.Ing., Professor of Mechanical Technology, Facoltà da Ingegneria, Istituto di Macchine, Technologie e Meccanica Agraria, Università di Pisa, Pisa, Italy.

COLLINS, Alfred Drew, M.A., A.R.I.C., Chief Chemist, Dominion Lead Mills, Ltd., Newmarket, Auckland, New Zealand.

EVERHART, E. Wayne, B.S., Head, Corrosion Section, Department of Metallurgical Research, Kaiser Aluminum and Chemical Corporation, Spokane 69, Wash., U.S.A.

HEMLIN, Ernst Erik, Director of the Library, Chalmers Tekniska Högskolan, Storgatan 43, Göteborg, Sweden.

JOHNSON, Arthur Frederick, B.S., Staff Assistant to the General Manager, Western Brass Mills, Metals Division, Olin Industries, Inc., East Alton, Ill., U.S.A.

KIEFFER, Andreas Richard, Dr.phil.nat., Technischer Direktor und Geschäftsführer, Metallwerk Plansee G.m.b.H., Reutte/Tyrol, Austria.

KOCH, Wilhelm, Dr.-Ing.habil., Vorstandsmitglied, Vereinigte Deutsche Metallwerke A.G., Frankfurt (Main)-Heddernheim, Germany.

PATTERSON, Wilhelm, Dr.-Ing., Privatdozent und wissenschaftlicher Assistent, Giesserei-Institut der Rheinisch-Westfälischen Technischen Hochschule Aachen, Intzestrasse 5, Aachen, Germany.

ROBINSON, Michael Keller, Director, S.A. The Anglo Argentine Iron Co., Ltd., Pedro Mendoza 3865, Buenos Aires, Argentina.

ROBINSON, William Leslie, B.Sc., A.I.Mech.E., A.I.M., Divisional Investigator, Scientific Department, National Coal Board, Central Laboratory, N.W. Division, Shade House, Bolton Road, Pendlebury, near Manchester.

ROGERS, Philip S., B.S., Senior Engineer, Research Section, Engineering Department, Harrison Radiator Division, General Motors Corporation, Lockport, N.Y., U.S.A.

SAWAMOTO, *Professor* Hachie, D.Eng., Professor of Non-Ferrous Metallurgy, Faculty of Engineering, Nagoya University, Nagoya City, Japan.

SEBISTY, John J., B.A.Sc., Department of Mines and Technical Surveys, Ottawa, Ont., Canada.

SOUTHERN, George Arthur, Foundry Technical Assistant and Development Engineer, Foundry Test Room, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester 17.

TANIMURA, *Professor* Hiromu, D.Eng., Metallurgical Department, Faculty of Engineering, Kyushu University, Fukuoka, Japan.

WALLACE, John Bruce, Chairman and Managing Director, Die Casters, Ltd., 126 Cromwell Street, Collingwood, N.5, Vic., Australia.

WEIS, Elmer Jack, Vice-President and Director of Sales, Pacific Pumps, Inc., 5715 Bickett Street, Huntington Park, Calif., U.S.A.

WILKIE, (Mrs.) Margaret Elizabeth, B.Sc., L.I.M., Experimental Officer (Metallurgist), Ministry of Supply, Royal Ordnance Factory, Patricroft, Lancs.

As Junior Members

GARDINER, John Howard, Student, Department of Metallurgy, Battersea Polytechnic, London, S.W.11.

SIMMS, Ross Lowndes, B.Sc., Metallurgist (Development), High Duty Alloys, Ltd., Wern Works, Briton Ferry, near Neath, Glam.

As Student Members

ALBERT, Henry John, S.M., Graduate Student and Research Assistant, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass., U.S.A.

APSLEY, Samuel Dougan, Metallurgist, Sterling Metals, Ltd., Northey Road, Coventry.

CHALLIS, William Edmund, Metallurgical Chemist, The National Smelting Co., Ltd., Fryers Road, Bloxwich, near Walsall, Staffs.

DENTON, Brian, B.A., Metallurgist, Rolls-Royce, Ltd., (Motor Car Division), Pym's Lane, Crewe.

JONES, Alun, Undergraduate, Metallurgical Department, University College, Singleton Park, Swansea.

KEAR, Bernard Henry, Undergraduate, Department of Metallurgy, University of Birmingham.

LONGSTAFFE, David Allan Harrison, Undergraduate, Department of Metallurgy, University of Manchester.

ROBINSON, James Alan, Undergraduate, Department of Metallurgy, King's College, University of Durham, Newcastle-upon-Tyne.

ROSE, Richard Gordon, B.Sc., Research Student, Department of Metallurgy, University of Liverpool.

SHAFFIQ-UDDIN AHMED, A. H., 9 Shambazar Street, Calcutta 5.

WILLIS, Ralph Lloyd, Undergraduate, Department of Metallurgy, University of Manchester.

"Journal" and "Metallurgical Abstracts" Volumes Urgently Required

The Institute will pay £1 each for bound volumes, in good condition, of the following:

Journal: 1940 (vol. 66) and 1942 (vol. 68).

Metallurgical Abstracts: 1940 (vol. 7), 1941 (vol. 8), 1942 (vol. 9), 1943 (vol. 10), and 1945 (vol. 12).

The following monthly parts of the *Journal and Metallurgical Abstracts* are also urgently required, and the Institute will pay 7*s.* 6*d.* for each copy in good condition:

1940: March, April, July, Aug., Sept.
1941: July, Aug. 1942: July.
1943: May, July, Aug., Sept., Oct.
1945: Jan., Feb., April, May.

PERSONAL NOTES

MR. M. G. BADEN, having completed his whole-time service with the Royal Air Force, has taken up a Research Studentship at the Battersea Polytechnic.

MR. F. B. DIANA has resigned his position as Vice-President and General Manager of Z. Wagman and Sons, Ltd., Toronto.

MR. E. H. DIX, Jr., Assistant Director of Research to the Aluminum Co. of America, has received the Frank Newman Speller Award of the National Association of Corrosion Engineers, in recognition of his important contributions to corrosion engineering, particularly in relation to aluminium and magnesium alloys.

DR. F. A. FOX has been appointed Chief Superintendent, Chemical and Physical Research Laboratories, Department of Supply, Salisbury, South Australia.

MR. D. HARDIE has been awarded the Ph.D. degree of the University of Durham, and has now taken up an appointment as Scientific Officer with the Division of Atomic Energy.

MR. R. G. HARPER has been appointed a Director of Fry's Metal Foundries, Ltd.

MR. E. HUNTER has been appointed Deputy Managing Director of Court Works, Ltd., Madeley, Salop. He was previously with the Incandescent Heat Co., Ltd., Smethwick.

MR. P. NAOR has left the University of Chicago, and is now engaged in the Metallurgical Laboratory of the Israel Institute of Technology, Haifa, Israel.

MR. G. C. E. OLDS has been awarded the Ph.D. degree of London University.

PROFESSOR ALBERT PORTEVIN has been raised to the rank of Grand Officier of the Légion d'Honneur.

MR. J. A. SABATO, who has now returned to the Argentine, wishes to thank all those who assisted him during his recent visit to this country.

SIR ARTHUR SMOUT has accepted an invitation to become Chairman of the Company which it is proposed to set up to organize the London Section of the British Industries Fair.

DR. D. SUMMERS-SMITH has left the A.E.I. Research Laboratories, and is now with Imperial Chemical Industries, Ltd., Billingham Division.

DR. H. SUTTON, while on an official mission to Australia, was entertained to dinner on 4 February by members of the Federal Executive and the Melbourne Branch Council of the Australian Institute of Metals.

MR. P. C. THORNTON has left the Plessey Co., Ltd., Ilford, to become a Lecturer in the Metallurgy Department of Battersea Polytechnic.

DR. W. H. J. VERNON has retired from his official post at the Chemical Research Laboratory, Teddington.

DR. A. J. C. WILSON has been appointed Professor of Physics at University College, Cardiff. He has been Senior Lecturer and Director of the Viriamu Jones Research Laboratory at the College since 1945.

Deaths

The Editor regrets to announce the deaths of:

PROFESSOR KOTARO HONDA, formerly of the Tohoku Imperial University, Japan, on 12 February, aged 83.

MR. HENRY BRIDGES WEEKS, formerly of Vickers-Armstrongs, Ltd., at St. Albans, on 20 February, 1954, at the age of 90 years. He was an Original Member of the Institute, and served as a Member of Council from 1920 to 1938.

MR. JAMES HOWARD WILSON, Chairman of Evered and Co., Ltd., Smethwick, and an Original Member of the Institute, on 9 February, aged 77.

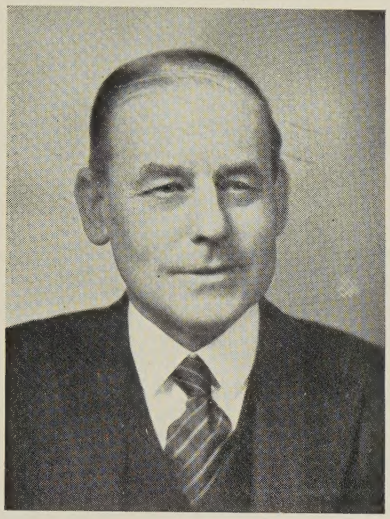
NEW OFFICERS

Below are given some biographical details of members who take office as President, Vice-Presidents, and Ordinary Members of Council at the Annual General Meeting on 27 April.

Dr. S. F. Dorey

(President)

Stanley Fabes Dorey was born in 1891, educated at Owen's School, London, and served an apprenticeship at the Royal Dockyard, Chatham. He received his academic training at



Armstrong College (now King's College), Newcastle-upon-Tyne where he attended from 1912 to 1914 with a Whitworth Exhibition and the first Lloyd's Register Scholarship in Marine Engineering to be offered to that College, obtaining the B.Sc. degree, Durham University, with distinction in Marine Engineering.

During the 1914–18 War he served as an Engineer Lieutenant in the Royal Navy.

In 1919, after a few months with Sir W. G. Armstrong Whitworth and Co., Ltd., at Elswick, he was appointed an Engineer and Ship Surveyor to Lloyd's Register of Shipping; after service at a number of ports, he was posted to the staff of the Chief Engineer in 1924, and at the end of 1932 was himself appointed Chief Engineer Surveyor.

Dr. Dorey has served on the Mechanical Engineering Research Board, the Fire Research Board, the British Shipbuilding Research Association Board, and the British Welding Research Board; he is a Vice-President of the British Internal Combustion Engine Research Association, and a Visitor of the British Welding Research Association.

He is a Past President of the Institution of Mechanical Engineers, the Institute of Marine Engineers, the Institute of Refrigeration and the Whitworth Society, and is an Hon. Vice-President of the Institution of Naval Architects. He is also a member of the Institution of Civil Engineers and of the Iron and Steel Institute. Dr. Dorey has served on the General Council of the British Standards Institution, and for some years was Chairman of the Mechanical Engineering Industry Committee. He is a Freeman of the City of London and a Liveryman of the Worshipful Company of Shipwrights.

He received the Honour of C.B.E. in 1946, for services during the 1939–45 War, was elected a Fellow of the Royal Society in 1948, and served as a Member of Council of that Society in 1950. He was made a Foreign Member of the Danish Academy of Technical Science in 1951.

Dr. Dorey has contributed a large number of papers to various technical institutions, including the Parsons Memorial Lecture to the Institute of Marine Engineers in 1942, the Thomas Lowe Gray Lecture to the Institution of Mechanical Engineers in 1941, the Edward Williams Memorial Lecture, entitled "The Contribution of the Steelfounder to Marine Engineering", to the Institute of British Foundrymen in 1943, and the Watt Anniversary Lecture for 1950 to the Greenock Philosophical Society. He has also been honoured by a number of awards from engineering institutions.

Dr. Dorey was elected a member of the Institute of Metals in 1933. He served as an Ordinary Member of Council from 1936 to 1940, and has served three times as Vice-President (1940–43, 1948–51, and 1952–54).

Dr. Maurice Cook

(Vice-President)

Born at Hartlepool in 1897, Maurice Cook received his metallurgical education and training at the Universities of Manchester and Cambridge. He graduated B.Sc., with first class honours in Metallurgy, in 1919, and was awarded the Leblanc Medal. He obtained the M.Sc. degree in 1920, and was subsequently awarded the Ph.D. (Cambridge) and D.Sc. (Manchester) degrees and the Honorary Associateship of the Birmingham College of Technology.

From 1919 to 1921 he was engaged in research and lecturing at Manchester University, and from 1921 to 1924 he carried out research in the Goldsmiths' Laboratory at Cambridge. From 1924 to 1926 he was on the technical staff of Messrs. C. A. Parsons and Co., Ltd., Newcastle-upon-Tyne. He

joined the staff of Kynochs, Ltd., in 1926, became Research Manager of the Metals Division of Imperial Chemical Industries, Ltd., in 1938, was appointed a Director in 1942 and a Joint Managing Director in 1951.

Dr. Cook has served on the General Council of the British Standards Institution, the Inter-Service Metallurgical Research Council, the Welding Research Council, the Council of the

Electrodepositors' Technical Society, and the Ministry of Supply Metallurgy Committee, and he has been Chairman of the Midland Metallurgical Societies, President of the Birmingham Metallurgical Society, and President of the Institution of Metallurgists, of which he is a Founder Fellow. He is a Vice-Chairman of the British Non-Ferrous Metals Research Association Council and Chairman of the Research Board, Chairman of the Metallurgy Advisory Committee of the City of Birmingham Education Department, and a member of Council of the Aluminium Development Association.

He is the author of many papers, about forty of which have been published in the Institute's *Journal*, covering a wide range of non-ferrous metallurgical subjects, including the constitution of alloys, the physical and mechanical properties of metals and alloys, deformation, recrystallization and grain growth in metals, metal melting, casting, and rolling, the testing of materials, welding, electrodeposition, and the history of metallurgy.

Elected a member in 1918, Dr. Cook has rendered prominent service to the Institute of Metals. He was Chairman of the North-East Coast Local Section in 1926–27, Chairman of the Birmingham Local Section in 1934–36, served as a Member of Council from 1939 to 1943, 1947 to 1951, and as Vice-President from 1943 to 1946. He has been a member of most of the Institute Committees, and as a member of the Publication Committee, in particular, for many years gave invaluable advice and practical assistance.

Dr. L. B. Pfeil

(Vice-President)

Leonard Bessemer Pfeil was born in London in 1898, and was educated at St. Dunstan's College and Woolwich Polytechnic. After service in the R.F.C., he went to the Royal

School of Mines, where he obtained the A.R.S.M. in 1921, with the award of the Bessemer Medal. In the same year he graduated in the University of London, with first-class honours in Engineering Metallurgy, and later obtained the M.Sc. and D.Sc. degrees of the same University.

In 1921 he became Assistant Lecturer in Metallurgy in the University College of Swansea, and in 1927 was appointed Lecturer, a position which he occupied until 1930, when he joined The Mond Nickel Co., Ltd., as Assistant Manager of the Research and Development Department, with charge of the Research Laboratory at Birmingham. For the next fifteen years Dr. Pfeil directed research on a wide range of ferrous and non-ferrous materials, including the constitution of non-ferrous alloys, age-hardening of alloys, high-temperature materials, the transformation characteristics of steels, hardenability, the response of steels to heat-treatment, and powder metallurgy. During the war, Dr. Pfeil was responsible for research on high-temperature alloys for aircraft gas turbines, which led to the development of the well-known series of "Nimonic" alloys; he was also closely associated with other investigations connected with the war effort. He was awarded the O.B.E. in 1947.

Dr. Pfeil has participated, for many years, in co-operative research in the metallurgical field, and has been called upon to serve on various Governmental Committees dealing with the properties and control of metals and alloys, including the Inter-Service Metallurgical Research Council and the Metals Economy Advisory Committee to the Minister of Supply. He also takes an active interest in scientific and technical education, and was a member of the Joint Education Committee set up by the five Metallurgical Institutes to consider the education of metallurgists.

In 1945 Dr. Pfeil became Manager of the Development and Research Department of his Company, with headquarters in London, and in 1951 was made a Director of the Company. He is also a Director of its associate, Henry Wiggin and Co., Ltd. In 1951 he was elected a Fellow of The Royal Society.

Dr. Pfeil's membership of the Institute of Metals dates from 1923. He served on the Council from 1945 to 1949 and again from 1950 to the present time; he has also acted as Chairman of the Publication Committee. In 1946 he was elected a Fellow of the Institution of Metallurgists, of which he is now President.

Major P. Litherland Teed

(Vice-President)

Philip Litherland Teed was born in 1889, and educated at Dulwich College and the Royal School of Mines. He served in the First World War in the Royal Naval Air Service and Royal Air Force in France and other areas. Subsequently he became Head of the Gas and Chemistry Section of the Inter-Allied Aeronautical Commission of Control (Germany).

Major Teed joined the Vickers Group in 1924 and is now Deputy Chief of Research and Development, Vickers-Armstrongs, Ltd. (Aircraft Section), Weybridge. During the Second World War he served first as Deputy Director of Material Production in the Ministry of Aircraft Production, and subsequently as Metallurgical Adviser to the Minister of Production, and to the British Commonwealth Scientific Office in Washington.

In 1949 Major Teed was invited to lecture at the International Aeronautical Conference in New York on "Materials from the Aircraft Manufacturers' Point of View", and in 1950, at the Massachusetts Institute of Technology, he lectured on "The Influence of Metallographic Structure on Fatigue". Last year he was awarded the Simms Gold Medal of the Royal Aeronautical Society for a paper on "Fatigue of Aircraft Materials, with Special Reference to Microstructure". In 1951 he was a member of an eight-man team which went to the United States under the auspices of the Anglo-American Council on Productivity to study and report on the conservation of strategic metals. Last autumn he led a British team that went to the United States to study titanium production and applications there.

His publications include "The Chemistry and Manufacture of Hydrogen", "Duralumin and Its Heat-Treatment",

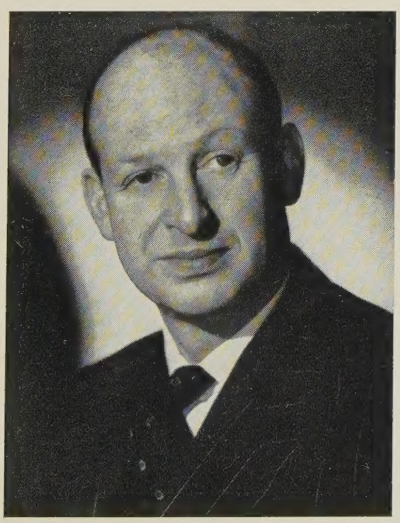
"Anglo-American Magnesium Production", "The Properties of Metallic Materials at Low Temperatures", and papers dealing with the chemistry and/or physics of materials.

Major Teed is an Associate of the Royal School of Mines in Mining and Metallurgy, a Barrister-at-Law (Middle Temple), a Member of the Institution of Mining and Metallurgy, a Fellow of the Institution of Metallurgists, a Fellow of the Royal Aeronautical Society, and an Honorary Member of the Society of Licensed Aircraft Engineers. He joined the Institute of Metals in 1931.

Mr. R. D. Hamer

(Ordinary Member of Council)

Robert Dennis Hamer was born in 1913 in London and educated at the University of Saskatchewan, Canada, and



Charlottenburger Technische Hochschule, Germany. After a short period of industrial experience in Europe, he joined the Aluminium Company of Canada Limited in 1936 as a chemical engineer. In 1945 he transferred to Aluminium Laboratories Limited, Montreal, the technical management company of the Aluminium Limited group of companies, and five years later he was put in charge of Aluminium Laboratories Limited's offices in Europe, with headquarters at Banbury, and became a Vice-President and Director of the company in the same year. He is also a Director of the Magnesium Company of Canada Limited, Montreal.

Mr. Hamer is a Fellow of the Institution of Metallurgists, currently President of the Aluminium Development Association, a member of Council of the British Non-Ferrous Metals Research Association, and a member of the Inter-Service Metallurgical Research Council.

Mr. G. P. Tinker

(Ordinary Member of Council)

George Parker Tinker was educated at Epworth College, Rhyl, and subsequently at the Victoria University, Manchester. There he obtained a B.Sc. (Metallurgy) degree with first-class

honours and was awarded the Le Blanc Medal for a paper on electrochemistry. He continued his academic career with a year's research in metallurgy and proceeded to the degree of M.Sc.

Mr. Tinker's entire business career has been concerned with the manufacture of electric furnaces. In 1925 he joined Henry Wiggin and Co., Ltd., to take charge of the newly formed Electric Furnace Department.

In 1927, on the formation of Birmingham Electric Furnaces, Ltd., later Birlec, Ltd., Mr. Tinker became assistant to the General Manager. He was appointed a Director in 1946, and Managing Director in 1950, which position he holds to-day. He has been a Director of Maiden and Co., Hyde, Cheshire, since 1940.

Mr. Tinker has been a Member of the Institute of Metals since 1921, and he is also a Member of the Institute of British Foundrymen and the Iron and Steel Institute, and a Fellow of the Institution of Metallurgists. He served as a Member of the Machine Tool Trades Association Council (Allied Trades Section) in 1952 and 1953.

Mr. Tinker has travelled widely, and has visited the United States, India, South Africa, and Australia several times.

B6 LUBRICANTS FOR METAL-WORKING OPERATIONS IN THE NON-FERROUS METALS INDUSTRY

On Wednesday, 6 January 1954, at the University, Edgbaston, Birmingham, an all-day Informal Discussion on "Lubricants for Metal-Working Operations in the Non-Ferrous Metals Industry" was held under the auspices of the Metallurgical Engineering Committee. The Chairman of the Committee, Mr. W. J. Thomas, M.I.Mech.E., occupied the Chair, and there was a large attendance.

The discussion had been arranged to allow an exchange of practical information on the subject and so that users and suppliers might consider together the problems involved. Machinery lubrication and lubrication in machining operations were not covered. The morning session dealt with hot working and that held in the afternoon with cold working.

The general conclusion was reached that lubrication was becoming a science and that users, to meet the requirements for quality in their products, were working under stringent conditions which made increasing demands on the lubricants. Makers of lubricants had now largely overcome supply difficulties, and it was to be hoped that better collaboration between them and the users would lead to the solution of outstanding problems. Mention was made during the discussion of some of the entirely new chemical and mineral lubricants now being developed.

A summary of the main points of the discussion is given below.

LUBRICANTS FOR THE HOT WORKING OF LIGHT METALS

Experiences and Problems of Users

Rolling

In hot rolling aluminium and aluminium alloys without lubrication and under rolling pressure, the slabs can weld to the rolls. To prevent this, animal fats were initially used, but were later replaced by heavily compounded oils of high viscosity. These gave rise to staining and contamination of the blank surface, and the defects could persist throughout the cold-rolling process. It was sometimes necessary to clean the hot-rolled blank by means of a caustic soda pickle.

Demands for higher output, with attendant problems of overheating the rolls and lubricant flash-off, led to the replacement of the mineral-oil lubricants by oil/water emulsions. The soluble oils have brought new problems of roll-coating control and roll cracking. It has been found that forged steel rolls are better than chilled iron and are also more resistant to lubricant attack. In the opinion of one speaker the presence of an aluminium coating on the roll barrels, giving aluminium-to-aluminium contact, is desirable, as it provides a better entry for heavy passes and, on long passes, prevents the material running across the rolls.

Excessive roll coating gives rise to hot-mill coating defect due to flaking and rolling-in of the aluminium on the roll surface. The appearance of this defect is sometimes associated with a change in soluble-oil formula and with ageing or deterioration of the emulsion. A heavy coating can be provided by an unstable emulsion which may break down after a short period of service, but which provides good acceptance of the rolling slab, while a stable emulsion of high lubricity, giving little coating, may lead to difficulty with slab acceptance and skidding between work rolls and metal. Changes in formula between these two extremes have led to the development of present-day proprietary soluble oils, which, although greatly improved, still give rise to coating defect after an extended period of service. Ageing of the emulsion is a fundamental problem of hot-mill lubrication about which little seems to be known: there is scope for further investigation of this and of the whole mechanism involved.

The capacity of a hot-mill lubrication system depends on the size and throughput of the mill, but a reasonable-sized mill may have a circulating capacity of from 6000 to 20,000 gallons, in which optimum lubricant temperatures have to be maintained by heating and cooling units. A maximum emulsion temperature, usually about 30°–50° C., is observed in mills with fabric bearings.

Emulsion concentration is kept at a minimum of about 2%, but a lower concentration may be used on four-high mills, where contact between work and support rolls will reduce the roll coating. Higher concentrations can be permitted on hot-finishing mills, where the absolute reduction is smaller, but it is thought that a better control over lubricity can be obtained from constitutional change than by an increase in concentration, which leads to instability. In a typical mill the emulsion is applied to the hot-mill stand at about 300–350 gal./min., usually through sprays disposed for optimum distribution of the lubricant. The circulating system is also designed to provide for separation of extraneous bearing oils.

The essential routine sampling for concentration is under laboratory control, and figures for the total oils per cent. and alkalinity expressed as mg. KOH/100 c.c. are regularly given to mill supervision. An increase in alkalinity may be associated with changes in lubrication, and can be used as a rough warning of a possible breakdown in the lubricant.

Contamination of the lubrication system arises from attritus caused by friction at the metal/roll interface, metallic oxides and hydroxides from rolling a variety of alloys, and the build-up of mineral salts from water evaporation. Filters introduced into hot-mill circuits, usually of the mechanical type, are, in general, intended to separate grosser particles, rather than the finely divided contaminants. Much importance is attached to the cleanliness of the lubrication system.

The matt silvery finish of metal rolled hot with oil emulsion is related to the roll-barrel coating, and the quality standard of the blank also affects that of the finished product. It is, therefore, important to seek the best possible conditions for hot-mill lubrication.

At one new plant the availability of soft water has greatly

simplified the problem of maintaining the emulsion. With the elimination of some contamination, including mineral oils, achieved through tight laboratory control, several problems began to disappear, and this gave confidence to test the use of wetting agents. Improved control of the hot-rolling conditions was obtained, but there was found to be a subtle relationship between wettability and the pass programme being employed.

This experience was on a two-high reversing mill using a relatively weak emulsion. On the accompanying four-high tandem mill a somewhat similar emulsion could be used, but the difference in pass programmes and the drop in temperature gave rise to effects which had to be taken into account if a blank was to be produced.

Absence of staining is an essential feature of any oil used, particularly if after rolling the blank is to be coiled.

Chemical control is more satisfactory than mechanical doctoring, which introduces yet another factor to disturb the relation between blank and roll finish.

Extrusion

In extrusion the orthodox direct method depends on keeping the container bore slightly colder than the billet and extruding through a sharp-edged, or virtually sharp-edged, orifice. The troubles are slow speed and the familiar and inevitable back-end structure, but the billet does not require preparation and the extruded surface is good.

General dissatisfaction was expressed by speakers with the many lubricants tried. Among these were the silicone greases, which break down under the working pressures involved.

Theoretically, improved speed and quality can be obtained by streamlined, perfectly lubricated flow. This has in fact been achieved, and results in improved back-ends, but it can be maintained only by using expensive tools and specially prepared billets and by accepting an extrusion the surface of which is impregnated with lubricant. The use of barriers should assist streamline flow by preventing aluminium-to-steel contact. Pure aluminium may be used for this purpose, but it requires specially prepared billets, and the improvement in speed has been found to be less than expected ; moreover, the coating varies from front to back and is difficult to maintain, particularly at re-entrants and sharp corners, and blisters may occur.

Forging

In the case of forging and pressing, the problem is to get the metal to flow into a desired shape with a minimum of blows and reheats. Lubricants should give clean, defect-free surfaces with minimum deformation of extremities due to friction. High drag leads to an undesirable extrusion effect. Colloidal graphite suspended in oil has proved a good lubricant, but with deeper forgings the extrusion effect occurs, with resultant surface tearing and blistering. Absorption of the graphite by the oxide skin gives a dirty forging. Tallow is useful for small forgings where a good finish is required. Silicone greases have proved unsatisfactory. The trend would seem to favour coarser-flake graphite, which is not as liable as colloidal graphite to be absorbed into the oxide skin.

Comments by Lubricant Suppliers

It is fortunate that most mills are near to a soft-water supply, otherwise the emulsifiers would have to deal with calcium and magnesium salts. It is not to be expected that artificially softened water will prove satisfactory.

The *p*H of the emulsion should be near neutral if it is to be non-reactive to aluminium. A soluble oil consists of two parts, the emulsifiers—usually anionic soaps and sulphonides—and the mineral portion. Addition of wetting agents is made to the aqueous and not to the disperse phase.

Initial success has attended the use of anionic emulsifiers, which can be made nearer neutral, and there is some evidence that controlled instability, with gradual release of the disperse phase, is practicable and advantageous. It would be dangerous to postulate a very unstable emulsion.

Wetting Agents

Wetting agents, added to a good-quality oil, give improved control over the lubrication conditions of the hot mill.

Whatever the method of hot-rolling lubrication employed, the process operates by means of a medium which does not wet the aluminium, since the temperature of the metal, and also probably of the rolls at the area of rolling contact, is well above the spheroidal-state temperature for water.

The effective prevention of metal-to-metal contact calls for a lubricant which, among other properties, has adequate film strength and lubricity and which will thoroughly wet at least one of the contacting surfaces. The wetting properties of neat oil are much better than those of water mixtures. Improved lubrication can be obtained by the periodic addition of a selected wetting agent to an emulsion of an oil which is exceptionally stable. Additions are made to restore the wetting properties of the original emulsion, as deterioration takes place over a period of use. Control of the emulsion is by daily checks of emulsion strength and of wetting efficiency measured by the Draves test described in the "Method of Testing Manual," issued by the Institute of Petroleum.

All surface-active agents have a similar structure, one end of the molecule being oleophilic, or oil-soluble, the other hydrophilic, or water-soluble. It is the balance between the two parts of the molecule which determines the exact wetting properties, and it is the oleophilic end that predominates in the surface-active agents so far found to be effective. It can be postulated that the improved performance is due to the rolls becoming de-watered and wetted instead with oil.

It is found that a wetting agent cannot satisfactorily be added to every type of soluble oil, because of the risk of excessive and persistent foam, or the development of instability and excessive free oil. Difficulty is also experienced in the choice of wetting agent to give the required speed of wetting.

Practical trials on various types of mill have shown that while the problem is essentially the same for all plants, a standard procedure cannot be laid down and each plant must be considered on its own.

A complete answer to the hot-rolling problem has not yet been found. Even under ideal conditions an emulsion will not last for ever, but in trials an uncompleted life of from six to nine months has been obtained.

Filtration

There should be a relation between the size of the circulatory system and the rate of circulation. Emulsions are difficult to filter : the alternative is to settle-out some of the fines in large settling tanks.

Filtering by centrifuge can deal with large volumes, but the largest, with a capacity of 2000–3000 gal./hr., can hardly deal with a flow rate of 300–350 gal./min. of soluble oil, unless a large battery of machines were put down. Neither settling tanks nor centrifuges can remove the semi-colloids suspended in an emulsion.

LUBRICANTS FOR THE HOT WORKING OF OTHER NON-FERROUS METALS AND ALLOYS

Except in the case of the light alloys, development in the non-ferrous metals industry has lagged a little in some respects.

In hot working, it is to be questioned whether surface conditions of the tools and the work, and atmospheric influence, are not more important than the lubricant, which can, however, affect side spread and edge cracking.

Work on roll finishes is necessary where improved lubrication leads to failure of the work to bite and to skidding. Where water alone is used in hot rolling, some clarification of the effect of hardeners and control of the *p*H value are required.

It is to be questioned whether an oil for hot rolling magnesium has been found which prevents sticking to the rolls without introducing carbon residues.

It has been shown that glass and softer metals can be used as lubricants for harder metals. Could they be used in the non-ferrous heavy metals section ?

In the special application of hot pressing magnesium electronic components by a hobbing process at 350°–450° C., with a pressure of 3 tons/in.^{2} on the projected area, the best lubricant so far has proved to be an aqueous solution of finely divided graphite. Carbon pick-up has to be removed to avoid corrosion troubles. Molybdenum disulphide is difficult to apply evenly.

A fine interior finish has been obtained on redrawn magnesium rectangular tube, using finely divided graphite in an oil base.

Glass as a Lubricant

Glass fibre is being used in steel extrusion, and particularly for special nickel-steel tubes and sections. The form and composition of the glass used has to be developed for each process. There should be a wide application for such lubrication in the non-ferrous metals industry.

Viscosity is the most important of the properties of glass lubricants. The softening point of a glass is the temperature at which log (viscosity) is 7·6, and glasses used in steel extrusion soften at 730°–820° C. The operating range is 1000°–1200° C. when the log (viscosity) ranges from 2·6 to 4·9.

The devitrification properties must be considered if the process necessitates holding a reservoir of molten glass for several hours.

A large proportion of the glass lubricant will be removed by differential contraction during cooling. It is believed that glasses with melting points as low as 400° C. could be made.

Dispersions of glass in carriers such as aluminium have been prepared, and this product in the powder or semi-colloidal form is applied to the extrusion billet or forging blank.

Solid Additives

Of the solid additives, graphite has good lubricity and does not oxidize below about 600° C. Molybdenum disulphide is a good solid lubricant, but oxidation starts rapidly at 400° C. Vermiculite, which expands when heated, and talc are useful parting agents. Boron nitride shows promise. Camphor, which sublimates and does not have to be cleaned from surfaces after the forming operation, shows remarkable lubricity. Polytetrafluoro-ethylene has one of the lowest coefficients of friction recorded, but cannot be used for hot-working operations, as it softens.

Many solid lubricants are expensive, and the main problem in their application is to prepare a suitable dispersion, in which the additive is present in a carefully controlled particle-size.

LUBRICANTS FOR THE COLD ROLLING OF NON-FERROUS METALS AND ALLOYS

Experiences and Problems of Users

Rolling Practice

In sheet-mill rolling, with small reductions per pass and peak loads very little in excess of the compressive yield strength of the material being rolled, separate lubricants are used for roughing, intermediate, and final passes. Mineral oils of viscosity up to 100 sec. Redwood, and animal and vegetable oils have been used in roughing work. All aim at getting the maximum reduction per pass without skidding and without staining at the annealing stage. For intermediate rolling, the mixture used, generally having a viscosity of about 45 sec., depends on the lustre required after final rolling, and at final rolling very light oils, or even petrol, have been employed.

Aqueous emulsions, attractive because of their low fire risk and high specific heats as coolants, have been tried, but non-staining oils of 45–50 sec. viscosity have given better reductions and finishes on the slower two-high mills.

The lubricant is supplied in small quantities through drip-feed pipes or via the strip, which can be oiled before it enters the rolls. Wipers are used to distribute the oil over the roll barrel but tend to impart a streaky or " tramline " effect to the strip.

Drip-feed lubrication has been successfully used on four-high mills at speeds up to 200–300 ft./min., both for light- and heavy-pass work. At higher speeds the major problem of dissipating the heat developed has been solved by adopting flood lubrication, where the rolling lubricant also serves as roll-barrel coolant.

During heavy passes on the four-high mills mean pressures of 18 tons/in.^{2} and peaks of 30 tons/in.^{2} are realized, and a mean of 24 tons/in.^{2} and peaks of 36 tons/in.^{2} can be envisaged. Although well within the mechanical limits of the roll bearings and the electrical limits of the mill motor power, these heavier drafts cannot be rolled with existing lubricants. Failure is exemplified by defective surface. An oil of higher viscosity might assist, but would lead to danger of staining at the annealing stage. The aim is usually to obtain a bright strip surface, free from oil.

Annealing is sometimes carried out at a temperature higher than that required to soften the metal, in order to eliminate oil staining. This leads to excessive oxidation of the strip surface and possibly, on subsequent rolling, to a pick-up of oxide on the rolls.

Control of roll shape is maintained by either the hot-oil or cold-oil method. In the former, which gives rise to fuming, the oil runs 50°–60° F. (10°–15° C.) hotter than the cold oil.

Attritus, rubbed off the strip during rolling, can be tolerated

up to 0·15% before loss of lubrication is observed, but a maximum figure of 0·05% is preferred for reasons of quality. The attritus, measured as ash residue after ignition, can be removed by an absorptive filter such as Fuller's earth. Lanolin additives were formerly filtered out unless the oil was filtered at around 120° F. (49° C.), but oils of this type are now successfully filtered at 80° F. (27° C.). Oil is lost with an earth pack.

The circulatory roll-lubricating and coolant system of a tandem mill may contain up to 20,000 gal. which constitutes a serious fire risk. Flood lubrication involves a considerable capital outlay on fire-fighting equipment, fume extraction, pumping and filtration plants, and also the segregation and ventilation of mill electrical equipments. There is also the cost of running these auxiliaries, whose prime movers would rate up to 200 H.P. for a tandem mill. The large volume of oil in circulation can be completely spoiled by accidental leaks of the heavy oil from roll-neck bearings and of the special oil from the hydraulic system associated with mill auxiliaries.

Properties Required in a Rolling Lubricant

The properties required in a rolling lubricant, some of which appear to be incompatible, are:

(i) Good load-carrying capacity, to allow mills to be used to their full mechanical and electrical ratings.

(ii) Ability to permit bright annealing at 350° C. or, alternatively, non-cracking at high temperatures.

(iii) Ability to give a bright uniform finish.

(iv) A high flash-point to reduce the fire risk or, alternatively, non-inflammability.

(v) Volatility, to give a dry strip.

(vi) Free flowing and pumping readily at pressures of 100 lb./in.^{2}, without risk of Diesel effects.

(vii) Good characteristics as a coolant. An oil which will reduce the heat input to the rolls is desirable.

(viii) Stability, because of the large volumes in circulation.

(ix) Non-toxicity and not to be unpleasant to work with.

(x) Ease of filtration without loss of additives.

(xi) Suitability for roll-neck bearings and hydraulic systems.

(xii) Cheapness.

Comments by Lubricant Suppliers

The major problem in producing a lubricant is to marry load-carrying capacity to non-staining properties. A straight mineral oil will carry a load of only 9–10 tons/in.^{2}, and while viscosity, and load-bearing capacity, can be increased by the application of high pressure, this condition cannot arise in the roll gap, as the oil is not totally enclosed. The only practicable way to obtain the desired properties is to use additives.

It is the fatty acid content of the fatty oil additives which provides the required boundary lubricant and imparts high load-bearing capacity.

Two to 2½% free oleic acid in a mineral-oil base, which serves only as carrier and coolant, should not stain. The required amount of free acid can be obtained by adding enough oleon, but this mixture will stain because of undesirable substances in the oleon. For similar reasons lanolin is not a fully satisfactory additive.

During coil annealing, the oil distils at the coil centre. Then it emerges to meet an increasing amount of air until, at the edges, there is free access. Distillation, thermal cracking, and oxidation are all involved. The stipulated temperature for annealing, 350° C., presents a difficulty.

If rolling oils are to serve bearings, the bearings will have to be designed for the rolling oil. Similarly, with suitable pumps, it should be practicable to serve hydraulic systems. It is questionable whether leaking seals and hydraulic joints, even at accidental frequency, have to be accepted.

Non-inflammable oils might possibly be made available at 25–40s./gal. Non-petroleum oils, being used abroad as roll-neck lubricants, are not good lubricants. They are costly and unstable, and the oxidation products, if not inhibited, are corrosive to some bearing metals. If, however, they leak into the rolling oil they do not produce staining.

Filtration in a Flood-Lubrication System

Mechanical strainers and earth-type filters are available. It is not practicable to deal with the total circulation of a flood-lubrication system by earth filtration, but it is usual to work with two oil-storage tanks, from one of which the mill is fed with clean oil, while dirty oil from the mill is returned to the other.

Filtration takes place in two stages, rough straining between the dirty and clean oil tanks to ensure that all oil going to the mill is strained, and earth filtration with which fine straining may be incorporated. The fine, earth, filtration works on a by-pass from the clean oil tank. By-pass rates of 10–25% of the full flow to the mill have been found satisfactory. The degree of filtration is less than 1 μ, using a filter powder of diatomite with or without Fuller's earth.

Earth filtration has been applied to aluminium strip and foil mills and to a Sendzimir mill rolling stainless steel. Substantially the same system could be applied in wire drawing and in certain applications where the coolant is a soluble oil/water mixture, by selection of a suitable filter powder.

When considering filtration in relation to the permissible level of contamination in the bulk, the rate of by-pass to the filters has to be such that they receive oil with contamination at the rate at which the contamination is being introduced into the oil.

The Function of a Lubricant in Strip Rolling

In rolling, the entering, thicker strip obviously moves more slowly at the point of entry than the rolled, thinner strip at the point of exit. Since the rolls revolve at constant speed, they move faster than the strip at entry and slower than the strip at exit. At one point only in the roll-gap can the rolls and strip move together. The frictional forces will be inwards on one side and inwards on the other so that they set up a compression in the roll gap. If there were no friction the rolling force would be equal to the yield stress of the metal × the length of the contact × the width of the strip. Friction contributes to the compression factor, which increases the force required to deform the metal.

Variation in coefficient of friction will result in variation in gauge. The limiting thickness on tinplate, that is, the minimum thickness to which the strip can be rolled on a given mill, is reduced by reducing the coefficient of friction.

It is well known that gauge decreases as speed increases. It has been shown experimentally, in the rolling of steel strip, that there is a gauge drop of 0·008 in. between 10 and 300 ft./min. with a rolling oil, but no drop in gauge with graphite. The speed effect is entirely due to the lubricant, and the coefficient of friction is found to fall as speed increases.

The surface finish obtained on a strip is not a function of the rolling oil; it is a function of the rolling conditions, one of which is the rolling oil. To obtain a good finish it is essential correctly to locate the neutral axis.

LUBRICANTS FOR THE COLD DRAWING OF NON-FERROUS METALS AND ALLOYS

Drawing of aluminium and other non-ferrous metal wire is carried out on both slip and non-slip machines. In both types of machine, but more especially in the former, the lubricant acts both as a lubricant and a coolant. In its role as a drawing lubricant, it has to ensure a high-quality finish coupled with maximum die life and, in doing so, must reduce the friction at the wire/die interface to a minimum, thereby lowering both the power needed for the draft and the heat formed in the die. In slip machines, lubrication conditions between the wire and the drawing drums or cones also constitute an important factor. As a coolant, the lubricant must assist in the rapid dissipation of the heat which is inevitably built-up, not only as a result of friction, but also owing to the plastic deformation of the wire being drawn.

The viscosity of the lubricant is important, since, apart from any bearing which this factor may have on actual lubrication within the die, it affects both the efficiency of circulation and the extent to which metallic fines may be removed from the lubricant. Furthermore, in slip-type machines, a lubricant which is too heavy or tacky causes sticking on the faces of the drawing cones and results in breakages of the wire.

For heavy and medium copper and copper-base alloy wire drawn on slip machines, oil-in-water emulsions have been most commonly used. Such emulsions are normally prepared by digesting proprietary pastes with water, the pastes themselves consisting of a mixture of fats, soaps, fatty acids, and mineral oils and containing a certain amount of free alkali. An essential factor in the preparation of these emulsions, for which a *p*H value of 8·5–9·0 is usually desirable, is the type of water used. Lubricants of this type are best used from central lubrication systems, where it is possible to obtain the maximum degree of separation of metallic fines and to maintain adequate control of concentration.

Fatty oils, such as lard or castor oil, and soaps which form emulsions with water are also used for drawing copper and bronze wire. For finer-gauge wires, oil-in-water emulsions based on soluble oils are normally employed, care being taken that the *p*H value of such solutions is not reduced as a result of hydrolysis of the fatty content or by the absorption of carbon dioxide from the air. For single-block drawing at slow speeds, dry soaps, undiluted pastes, beeswax, tallow, wool-grease, or compounded mineral and vegetable oils are used in a greasebox in front of the die.

Lubrication problems associated with the drawing of aluminium wire differ from those appertaining to copper. For heavy and medium aluminium and aluminium alloy wires oil-in-water emulsions have not been found to be effective, and normally mineral oils, sometimes with fatty additives, have been used. Whilst the use of such oils has hitherto given satisfactory lubrication within the die, their viscosity—frequently as high as 900 Redwood sec.—has accentuated the problems associated with circulation and filtration and the incidence of staining after annealing.

Medium-gauge aluminium wire is now being drawn at speeds of the order of 3000 ft./min., which are appreciably higher than those employed when cylinder oils were first found to be satisfactory lubricants for drawing aluminium wire. There is evidence today that, at these higher speeds, the effectiveness of mineral oils as lubricants for this purpose is beginning to fall off. It is not unlikely that this may be associated with the higher temperatures now being encountered at the wire/die interface, and that future development may lie in refrigeration of the wire-drawing dies.

Concurrently with the increase in drawing speeds, both the capacity of the lubrication systems and the rate of circulation of the lubricant have increased in aluminium wire-drawing machines. With these factors in mind, together with the necessity for reducing the incidence of staining after annealing, the aluminium wire industry is now looking to the oil industry to provide a drawing lubricant with the lowest possible viscosity.

Most of the lubricants used for the cold drawing of non-ferrous metals have been developed as a result of practical experience on the shop floor without a detailed knowledge of the conditions existing in the drawing die. Recently, research has been directed towards an elucidation of the conditions at the metal/die interface. It is hoped that the results of this work will be capable of application by oil technologists to provide lubricants more suited to use in modern high-duty drawing machines.

In recent years, some attention has been directed towards the use of " extreme-pressure " additives in lubricants for tube and wire drawing. In gear lubrication, the effectiveness of such additives is considered to be due to their reaction with the metal surfaces at points of localized high temperature, with the resultant formation of low-shear-strength compounds which enable rubbing to continue without destruction of the surfaces. The conditions present in cold drawing are somewhat different since the metal is at little above room temperature until it is drawn into the die, when it achieves its maximum temperature in a fraction of a second. Under such conditions, in order to be effective, additives must be capable of reacting with the metal surface at the temperatures existing before the metal enters the die. It may be that, in time, new " extreme-pressure " agents will be produced which will, to some extent, meet these requirements, but, so far, it has not been found that they offer very significant benefits.

Informal Discussions

Members may be interested to know that a full transcript of the discussion on " Lubricants for Metal-Working Operations ", summarized above, is available for consultation at the Institute's offices. As there is only one copy, however, it cannot be sent on loan. The earlier discussions organized by the Metallurgical Engineering Committee are also available.

LETTER TO THE EDITOR

Stress-Cracking of Copper and Brass by Molten Metals

In connection with Professor Greenwood's letter on the stress-cracking of copper by mercury,[1] attention may be drawn to an earlier and interesting observation by Rawdon.[2] He stated that " soft annealed sheet copper, when thoroughly amalgamated with mercury, is very brittle and breaks with a rough intercrystalline fracture. The mercury may be easily volatilized by gently heating the specimen and the copper again shows its usual ductility."

Preliminary experiments by the present writers largely confirm this statement. Very soft copper sheet of large grain-size was used, the copper being free from phosphorus and oxygen. Specimens were immersed for half an hour in 1% mercurous nitrate solution containing 1% nitric acid, and were then bent, on removal from the solution. Quite distinct intercrystalline cracking was apparent, starting from the tension side of the specimen, by the time the metal had received a 120° unsupported bend. The mercury was then removed by heating the specimen gently, heating being continued for a short time after the visible mercury had disappeared. In this condition the copper sustained a 180° bend without cracking.

It should be noted also that some weakening in the tensile test, mainly in the form of lowered elongation values, of fully annealed tough-pitch copper strip (containing 0·045% arsenic) coated with mercury was detected by Moore *et al.*,[3] who reported the fracture as " fibrous ". On the other hand, no weakness was found for the same copper in the cold-rolled condition. Experiments were also carried out on annealed and cold-rolled strip made from manganese-deoxidized electrolytic copper. No cracking was experienced in cups spun from this material when subjected to the mercury test, nor in mercury-coated tensile specimens under a constant load equal to 1 ton/in.^{2} less than the breaking load.

In addition, Hartley [4] found that copper, in the form of soft wire, was weakened under tension by contact at 240° C. with molten tin and solder. The cracking was thought to be intercrystalline. However, some of the weakening is likely to have been due to general alloying.

It is, of course, well known that plain and alloyed brasses are susceptible to stress-cracking in contact with mercury at room temperature, as with molten metals such as solder and tin; this is shown for example, for a wide range of alloys, by the work of Dickenson [5] and of Voce.[6] Cracking is intercrystalline in the pure α and β alloys. In the α/β alloys there is often a tendency for the penetration to follow the phase boundaries or to show preference for the β-phase.[2, 5-7]

The β-phase brasses are by far the most susceptible to this kind of failure, with α-brasses considerably more resistant; pure copper is the least susceptible. That is, susceptibility increases with increasing stiffness of the metal and becomes most marked in the material having generally large grains with smooth boundaries. The α/β alloys appear to offer somewhat similar resistance to cracking to that of the α alloys, but quenching an α/β alloy so that its structure becomes entirely β markedly increases susceptibility.[4] The general run of evidence, therefore, indicates that stress-cracking by molten metals of copper and its alloys with zinc is favoured by the presence of long, smooth, grain boundaries which are able to withstand a considerable stress before the metal yields. Such conditions will naturally provide sufficient boundaries which outcrop at the surfaces in contact with the molten metal.

On this basis, it would appear that previous cold working should have an inhibiting effect on stress-cracking by molten metals. This has been shown to be so with respect to mercury for externally stressed tensile specimens of copper [3] and 70 : 30 brass strip.[3, 8] Moreover, susceptibility of recrystallized 70 : 30 brass was found to increase with increase in grain-size.[8]

It is appreciated that the views expressed above subscribe to the importance of grain " interlocking " (as denoted by boundary contours) as a factor in intercrystalline stress-cracking, this idea being put forward originally by Rosenhain.[9]

Incidentally, Professor Greenwood's results [1] emphasize the value of tests to destruction in contact with the cracking medium during work on stress-cracking. Such tests have the advantage of detecting low susceptibility (even though the time of testing may be short), which may not be revealed by tests on internally stressed parts or on specimens under sustained stress.

A. R. Bailey
R. J. King

Constantine Technical College,
Middlesbrough.

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NEWS OF LOCAL SECTIONS AND ASSOCIATED SOCIETIES

London Local Section

At a meeting of the Section held at 4 Grosvenor Gardens, London, S.W.1, on 4 February, Mr. R. W. Douglas, of the Research Laboratories of The General Electric Company, Ltd., gave a lecture on :

Germanium and Silicon

The lecturer said that, when solid, the electrical conductivity of germanium increased exponentially with temperature at high temperatures and at lower temperatures was markedly dependent upon its impurity content. Thus germanium exhibited behaviour typical of a semi-conductor. In the new electronic devices, germanium having a resistance of 10 ohm-cm.^{2} was commonly used and a simple calculation showed that this corresponded to 1 part in 10^8 of the impurity governing the conductivity. The source of very pure germanium, in Great Britain, was flue dust, in which it was present in concentrations between 0·1 and 1%. The winning and refining of germanium from this flue dust was described, and the additional purification for zone melting, which depended upon the fact that the impurities were more soluble in the solid than the liquid, was outlined. The final process of drawing into a single crystal was illustrated.

Descriptions were then given in very simple terms of the mode of operation of junction rectifiers and transistors, and several demonstrations of their operation were given.

South Wales Local Section

The President (Professor F. C. THOMPSON) paid his annual visit to the Section, accompanied by the Secretary (Lieut.-Colonel S. C. GUILLAN), on the occasion of the meeting held at University College, Swansea, on 12 January.

The President briefly addressed the members and conveyed to them the good wishes of the parent Institute. Mr. J. CROWTHER (Chief Metallurgist, James Booth and Co., Ltd., Birmingham) then gave a lecture on:

Continuous Casting

The lecturer said that the development of continuous casting had resulted from a desire to increase metal yields by eliminating the scrap cut from top and bottom of each billet when cast individually, and by permitting the maximum utilization of a given piece of plant. Greater uniformity of product could also be achieved, and because of the direct water chilling possible, billets of large diameter could be obtained with a satisfactorily fine structure. This last property was particularly useful in casting aluminium alloys, although a practical limit to the cooling rate was set by the onset of billet cracking.

Continuous casting of aluminium alloys and brasses on the Junghans type of plant was well established, but for the former materials the most common method was the Alcoa "direct-chill" type. This cast a sequence of long billets discontinuously, but had the advantage of relative simplicity of equipment and of easy change of size or material cast. Methods for steel were in course of active development, and if serious practical problems could be solved, the ultimate scope of the method in the steel industry would be very wide.

The operation of the "DC" process for aluminium alloys and of the Junghans process for both aluminium alloys and brasses was discussed in some detail, with particular emphasis on the factors affecting the quality of the finished product.

In conclusion, the lecturer said that there were a number of industrial processes of more restricted application but of considerable technical interest, particularly in the case of the Asarco method of casting precision rod in copper-base alloys; the Hunter Douglas and Properzi methods had been developed in recent years for casting relatively small billets of special section for rolling into strip or wire.

At a meeting held at University College, Swansea, on 9 February, Mr. L. A. J. LODDER spoke on:

The Zinc Die-Casting Alloys

The lecturer dealt first with the development of pressure die-casting over the last hundred years and described the machines in use today and the general design of dies. He then dealt with the process of pressure die-casting and emphasized the rapidity of output which mechanization permitted.

He next considered the zinc die-casting alloys and their historical development, noting particularly the troubles associated with zinc alloy die-castings during the First World War and in the years immediately after. Pressure die-casting then suffered a set-back owing to the distortion, cracking, and brittleness exhibited in service by castings in zinc alloys. Intensive research in America led to the discovery that this phenomenon was due to intercrystalline corrosion which was caused by certain impurities, notably lead, cadmium, and tin, when aluminium was present as an alloying constituent. This work prompted the commercial production of zinc of 99·99+% purity as a basis for die-casting alloys. Standardized alloys were then developed and, of a series, two remain in use today and are covered by B.S.1004.

The advantages of aluminium as an alloying constituent and the influence of copper and magnesium were outlined, and the mechanical properties of the alloys in die-cast form were considered.

Particular stress was laid on the rigid limits imposed by B.S.1004 on the impurities lead, cadmium, and tin and the consequent necessity for a high standard of "good housekeeping" in foundries devoted to the zinc alloys.

The potentialities and applications of the zinc die-casting alloys were next considered, and a number of specimens was displayed to illustrate such features as fidelity of reproduction of detail, accuracy of casting, complexity of form, and adaptability to various finishing processes.

Finally, the lecturer gave some illustrations of American die-casting practice in relation to the question of productivity.

JOINT ACTIVITIES

Joint Committee for National Certificates in Metallurgy

The Joint Committee of the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of Metals, and the Institution of Metallurgists, in conjunction with the Ministry of Education, has issued its report on the progress of the scheme for the award of National Certificates in Metallurgy for the year 1952–53.

The Joint Committee has approved four new Schemes during 1953, three for Senior Courses and one for an Advanced Course, and other Schemes have received preliminary approval of their content.

The total numbers of approved Courses in operation during the session 1952–1953 were:

Senior Courses—Ordinary National Certificate	33
Contributory Centres, with Courses for the First Year or First and Second Years of the Senior Course	6
Advanced Courses—Higher National Certificate	20

Final examinations of the Course for Ordinary National Certificate have been held during 1953 at 31 Technical Colleges and for the Higher National Certificate at 17 Technical Colleges, for candidates who have satisfied the conditions laid down in Ministry of Education Rules 111, under which the Scheme is operated. In addition, 11 Colleges have held assessed examinations in mathematics during the year, as part of their Courses for the Ordinary National Certificate.

The Committee is pleased to report that: (*a*) 184 candidates have qualified for the award of an Ordinary National Certificate in Metallurgy and 116 candidates have qualified for the award of a Higher National Certificate as a result of final examinations held in 1953. (*b*) The records of a further nine candidates for the Ordinary Certificate and one candidate for the Higher Certificate have been approved by the Joint Committee, subject to the fulfilment of certain conditions. (*c*) Two candidates for the Ordinary and one candidate for the Higher Certificate, who entered the final examinations in previous years and whose records were approved by the Joint Committee subject to certain provisions, have qualified for the award of Certificates in 1953. (*d*) Distinctions have been gained by 17 candidates for the Ordinary Certificate and 17 for the Higher who have shown a very good grasp of their subjects, indicating a high degree of training and

knowledge in the particular subject in which the Distinction has been gained. (*e*) Prizes have been awarded to 26 successful candidates for the Ordinary Certificate and 24 for the Higher who have shown particular merit in the final examinations, from the Prize Fund established by the Iron and Steel Institute, the Institution of Mining and Metallurgy, and the Institute of Metals for the purpose.

Comparative figures of entries and successful candidates for the eight years since the institution of the scheme for National Certificates in Metallurgy in England and Wales are as follows:

Year	Technical Colleges	Number of Candidates			
		Entered	Awarded Certificates	With Distinction	With Prize Award
Ordinary National Certificate					
1946	4	23	23	4	7
1947	11	102	69	14	17
1948	15	123	74	12	16
1949	21	222	107	24	27
1950	20	281	142	23	26
1951	25	314	138	17	24
1952	28	334	186 *	22	31
1953	31	390	184	17	26
Higher National Certificate					
1946	—	—	—	—	—
1947	2	22	18	—	1
1948	8	38	22	1	2
1949	10	74	59	20	22
1950	11	62	42	8	10
1951	16	110	54	5	11
1952	16	132	120 *	16	22
1953	17	140	116	17	24

* The results of 8 candidates for the Ordinary Certificate and 17 candidates for the Higher Certificate whose records were not available in 1951 were included in 1952.

Attention was drawn in the Joint Committee's Report for 1952 to the revised regulations for admission to the examinations of the Institution of Metallurgists. Candidates holding an Ordinary National Certificate in Metallurgy in which chemistry and physics are assessed subjects in the final year and mathematics an assessed subject in the pre-final year will be regarded as satisfying the regulations for admission to the Institution's examinations for Licentiateship. The regulations also provide for partial exemption from the Licentiateship examination to holders of the Higher National Certificates, provided that the standard attained in a minimum of three subjects approaches the standard required for distinction.

The Joint Committee is now pleased to report that 15 of the successful candidates for the Higher National Certificate in Metallurgy in 1952 and 9 in 1953 attained the exemption standard of the Institution of Metallurgists and qualified for exemption from the Licentiateship examinations on a subject-for-subject basis in three or more subjects.

Symposium on Powder Metallurgy

A Symposium on Powder Metallurgy is being organized by the Iron and Steel Institute in association with the Institute of Metals. An Organizing Committee has been set up as follows:

Dr. Ivor Jenkins	The General Electric Co., Ltd. (*Chairman*).
Mr. L. J. Brice	Ministry of Supply.
Dr. W. D. Jones	Consultant.
Mr. D. A. Oliver, C.B.E.	B.S.A. Group Research Centre.
Dr. L. B. Pfeil, O.B.E., F.R.S.	The Mond Nickel Co., Ltd.
Dr. T. Raine	Metropolitan-Vickers Electrical Co., Ltd.
Mr. E. Robson	The Manganese Bronze and Brass Co., Ltd.
Mr. K. Headlam-Morley	The Iron and Steel Institute (*Secretary*).

The Symposium, which will probably be held at Church House, Westminster, on 1 and 2 December 1954, will cover both ferrous and non-ferrous aspects of powder metallurgy. There will be a small exhibition illustrative of powder-metallurgy components.

A large number of papers are being specially written for the Symposium and will be presented and discussed in three main Groups as follows:

I. Metal Powders and Their Assessment.
II. Research and Production Practice.
III. Production and Properties of Engineering Materials.

A circular giving particulars about the meeting will be issued later.

DIARY

The Institute

26 April. Forty-fourth Annual May Lecture: "The Domain Structure of Ferromagnetic Metals", by Professor L. F. Bates. Non-members will be welcome; tickets of admission are not required. (Royal Institution, Albemarle Street, London, W.1, at 6.0 p.m.)

27–30 April. Spring Meeting. Joint meeting with the Société Française de Métallurgie. For full details see the February issue of the *Bulletin*, pp. 71–76.

Local Sections and Associated Societies

6 May. Leeds Metallurgical Society. Annual General Meeting, followed by films. (Chemistry Department, The University, Leeds 2, at 7.15 p.m.)

18 May. London Local Section. All-day visit to Ford Motor Co., Ltd., Dagenham.

Other Societies

19 April. Sheffield Society of Engineers and Metallurgists. Film evening. (University Building, St. George's Square, Sheffield, at 7.30 p.m.)

20–24 April. Fourth International Conference on Electrodeposition and Metal Finishing. London.

22 April. Institution of Mining and Metallurgy. General meeting. (Rooms of the Geological Society, Burlington House, Piccadilly, London, W.1, at 5.0 p.m.)

28 April. Institute of British Foundrymen, London Branch. Annual General Meeting, followed by a film on "Dust Extraction". (Waldorf Hotel, London, W.C.2, at 7.0 p.m.)

28 April. Institution of Electrical Engineers, Supply Section. "Aluminium-Sheathed Cables", by P. M. Hollingsworth and P. A. Raine. (The Institution, Savoy Place, London, W.C.2, at 5.30 p.m.)

30 April. Institute of Metal Finishing, Sheffield and North-East Branch. Paper by E. A. Ollard. (Grand Hotel, Sheffield, at 6.30 p.m.)

4 May. Society of Chemical Industry, Corrosion Group. Annual General Meeting, followed by a discussion on "Corrosion and Design" by W. E. Ballard, W. S. Atkins, and E. Bateson. (Chemical Society, Burlington House, Piccadilly, London, W.1, at 6.30 p.m.)

13 May. Institute of Metal Finishing, North-West Branch. "Corrosion in Theory and Practice", by Dr. T. P. Hoar. (Engineers' Club, Albert Square, Manchester, at 7.30 p.m.)

Erratum

In the Diary of Scientific Meetings published on p. 83 of the February issue of the *Bulletin*, it was erroneously stated that an International Conference on Electron Microscopy would be held from 6 to 9 July. This Conference will in fact be held in London on 16–21 July, as stated later in the Diary.

APPOINTMENTS VACANT

ASSISTANT METALLURGIST required. Some knowledge of copper and its alloys desirable. Ability to write on technical matters will be an advantage. Salary according to qualifications, with generous superannuation. Apply, stating age, details of training, and experience, to the Secretary, Copper Development Association, Kendals Hall, Radlett, Herts.

COMPANY operating non-ferrous rolling mill in the Midlands, requires young man about 30 to train as assistant to Rolling Mill Manager. Some experience in similar position preferred. Must be keen, energetic, able to control labour, and have some mechanical ability. State experience and salary required. Box No. 363, Institute of Metals, 4 Grosvenor Gardens, London, S.W.1.

IMPERIAL SMELTING CORPORATION, LTD., invites applications for the post of Research Manager to take charge of staff in their new research laboratories at Avonmouth, where work is in progress on extraction metallurgy, metals and alloys, heavy chemicals, pigments, fluorine compounds, catalysts, fungicides, &c. Applicants should have good degrees in either chemistry or metallurgy and previous experience in management of a Research Group or Department in industry is essential. Salary will be according to experience and ability. Applications should be made in writing to the Secretary, Broken Hill Secretariat Ltd., 37 Dover Street, London, W.1, and should be marked Personal.

METALLURGIST required for research and development work. Write for application form to Sondes Place Research Institute, Dorking, Surrey.

SENIOR METALLURGIST required, preferably between 30 and 35 years of age with at least Second Class Honours Degree or equivalent. This is a responsible and progressive position with appropriate salary. Apply, Personnel Manager, McKechnie Brothers, Ltd., Rotton Park Street, Birmingham, 16.

THE ASSOCIATED ETHYL COMPANY, LTD., Northwich, Cheshire, require an ELECTROCHEMIST OR METALLURGIST to carry out investigations on corrosion and related problems, and on materials of construction. Applicants should not be over 35 years of age, should possess a good honours degree, and preferably have some research experience. Salary will be according to age, qualifications, and experience. The successful applicant initially will be required to work at Northwich, but eventually will be stationed permanently at Ellesmere Port.

Applications should be addressed to the Personnel Manager at the above address.

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